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APTERONA HELIX (LEPIDOPTERA: PSYCHIDAE), A PALEARCTIC BAGWORM MOTH IN NORTH AMERICA: NEW DISTRIBUTION RECORDS, SEASONAL HISTORY, AND HOST PLANTS

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Abstract.—New distribution records for *Apterona helix* (Siebold), an Old World bagworm moth detected in California in 1940 and in New York in 1962, are given for Michigan and Pennsylvania, and additional New York records are provided; populations in western and eastern North America are thought to represent separate introductions from Europe. Seasonal history, habits, and host plants of this parthenogenetic, polyphagous species are reported for populations observed in New York and Pennsylvania, and North American distribution and economic importance in Europe and North America are reviewed. Characters facilitating recognition of this psychid are provided, and the unusual helicoid or snail-like larval case is illustrated.

Members of the psychid genus *Apterona* Millière are endemic to the Palearctic region, with 7 species occurring in the Mediterranean area, west and central Europe, Asia Minor, Crimea, Caucasus, Iranian Plateau, and southcentral Asia (Kozhanchikov 1956). *Apterona helix* (Siebold), a parthenogenetic species, is widely distributed in central and southern Europe, ranging east to European USSR and Kirgiz SSR in central Asia and south to Iran (Strand 1912, Davis 1964).

The first confirmed North American record of *A. helix* was based on an infestation discovered at a private residence in Nevada City, California, in June 1940 (Kiefer 1940, Robinson 1953). In the western states, *A. helix* now occurs in the northern half of California (Eichlin 1985) and in portions of Idaho, Nevada, Utah (Davis 1964), Oregon (Every 1970), and Washington (Suomi 1986).

Apterona helix is also known in eastern North America, having been detected near Albany, New York (Loudonville), in June 1962 (Davis 1964); a second infestation was soon discovered in Albany. Eastern populations are believed to be the result of an independent European introduction rather than to have originated from the established western U.S. populations (Davis 1964). Lenox, Massachusetts (Adamski 1984), is the only other eastern record.

The name *A. crenulella* (Bruand) has been used in early (and some current) literature on this adventive species in North America. Some European workers considered *helix* to be a parthenogenetic form of *crenulella*, whereas others argued that they are distinct species. In revising the Western Hemisphere Psychidae, Davis (1964) retained *helix* as a "facultative, parthenogenetic form," noting interfertility between *crenulella* and *helix* might be expected but that "many

questions remain unanswered." *Apterona helix* is now accorded specific rank (Davis 1983, 1987).

Here we review its status as an economically important species, give additional localities for *A. helix* in New York, and report Michigan and Pennsylvania as new state records. We summarize our observations on seasonal history, habits, and host plants in the East and give morphological characters allowing this immigrant species to be recognized in the North American fauna.

Economic Importance

The European literature indicates that *A. helix* occasionally is injurious. It has been implicated in causing damage to apple, horticultural crops, and olive (*Rev. Appl. Entomol.* (A) 3: 393, 1915; 4: 210, 1916; 56: 553, 1968).

In Utah, *A. helix* has been observed skeletonizing leaves of apple trees and causing extensive damage to many range plants; it sometimes injures various cultivated plants and becomes a nuisance when it congregates on the walls and windows of homes (Tibbetts and Knowlton 1952, Knowlton and Roberts 1968). There also are records of severe damage to cherry foliage in an orchard (Knowlton 1961), leafmining injury to corn (Knowlton and Parrish 1965), and destruction of green color in three acres of barley and four acres of alfalfa (Knowlton 1966). In Idaho, *A. helix* was extremely abundant in alfalfa and sweetclover, causing considerable skeletonizing of the foliage (Gittins 1958). Marshall (1970) recorded heavy damage to strawberry plants in Nevada. In California, where this insect has been called the garden bagworm, considerable damage to several commercial crops such as apple, cruciferous vegetables, and chrysanthemums and other plants grown for cut flowers has occurred when populations are high (Keifer 1947, Robinson 1953). Suomi (1986) reported that baby's breath (*Gypsophila*, Caryophyllaceae) used in dried flower arrangements was so heavily infested in one Washington county that plant material could not be shipped out of state.

There are no reports of damage by *A. helix* to cultivated plants in eastern United States, although Adamski (1984) stated that cases were found attached to planted flowers and vegetables, ornamentals, and shade trees. In New York, the cases have attracted notice when they attach to houses (Davis 1964). Each year homeowners submit larval cases to Cornell University's Insect and Plant Disease Diagnostic Laboratory; their concern is with large number of cases that accumulate on houses and the paint that is sometimes removed when cases are pulled off (Klass 1983).

Distribution in Eastern North America

In addition to published records from the Albany, New York, area and Lenox, Massachusetts, the following new records are available. Michigan, Pennsylvania, and some of the New York records are based on our collecting; other New York records (those without collector names and mostly lacking exact localities) were obtained from the Insect and Plant Disease Diagnostic Laboratory, Cornell University. Voucher specimens have been deposited in the insect collections of Cornell University and the Pennsylvania Department of Agriculture.

MICHIGAN: *Kent Co.*, Wyoming, 5 May 1986, E. R. Hoebeke; Grand Rapids, 6 May 1986, ERH.

NEW YORK: *Albany Co.*, nr. Colonie, Pine Bush, 30 June 1984, ERH and A. G. Wheeler, Jr. *Broome Co.*, Binghamton, 23 July 1983, ERH and AGW. *Chemung Co.*, Rt. 17 N. of Wellsburg, 27 June and 1 August 1982, AGW. *Clinton Co.*, August 1983. *Columbia Co.*, June 1985. *Dutchess Co.*, Stanfordville, October 1984. *Erie Co.*, Tonawanda, 12 June 1983 and 22 June 1985, ERH. *Essex Co.*, May, November 1977. *Livingston Co.*, Dansville, June 1980. *Greene Co.*, East Windham, June 1984. *Monroe Co.*, Greece, 31 July 1982, ERH

and AGW. *Onondaga Co.*, Solvay, 26 June and 4 September 1982, 14 May 1983, ERH and AGW. *Ontario Co.*, Canandaigua, April 1979. *Rensselaer Co.*, Troy, June 1973. *Schenectady Co.*, August 1973. *Tompkins Co.*, Ithaca, 20 April 1987, ERH. *Ulster Co.*, May and September 1982. *Wayne Co.*, Clyde, 25 June 1983, ERH and AGW.

PENNSYLVANIA: *Erie Co.*, Erie, 11 July 1985, AGW. *Lackawanna Co.*, Carbondale, 28 June 1985, AGW. *Lebanon Co.*, I-81 at junc. I-78 NW of Jonestown, 20 August 1982 and March–August 1983, AGW. *Mercer Co.*, Sharon, 29 July 1987, AGW. *Susquehanna Co.*, Thompson, 28 June 1985, AGW.

Our collections of *A. helix* in Broome, Chemung, Erie, Monroe, Onondaga, Tompkins, and Wayne counties in New York; Erie, Lackawanna, Mercer, and Susquehanna counties in Pennsylvania; and Kent County in Michigan were made along or near railroad right-of-ways. In fact, populations were nearly always found only in a small area adjacent to active or abandoned trunk lines. In Lebanon Co., Pennsylvania, *A. helix* apparently is restricted to less than a mile of road near the junction of interstate highways 78 and 81.

It seems reasonable to assume that spread of this flightless, parthenogenetic moth in North America is largely dependent on commerce, especially rail traffic. Mature larvae are known to leave low-growing hosts and to attach to a suitable, usually higher, substrate for pupation (Robinson 1953). A larva could easily attach its case to a rail car in storage and the pupa, female, eggs, or overwintering larvae could be transported many miles to initiate a new colony. In one California orchard a new infestation of *A. helix* was attributed to its introduction as cases attached to a "small private spray rig" that had been used in the infested area (Armitage 1953).

Seasonal History and Habits

To obtain information on phenology of this psychid in eastern North America, collections were made in 1983 from a roadside planting and from guardrails at the junction of interstate highways 78 and 81 in Lebanon Co., Pa. Observations were made and cases collected on 30 March; 1, 13, 22, and 27 April; 5, 11, and 18 May; 2 and 21 June; 15 July; and 3 August. Populations at the site were not as large as the hundreds of old cases adhering to guardrails might suggest, and on several sample dates the bagworms were not easily found on vegetation; cases, which "resist weathering to an amazing degree" (Robinson 1953), probably persist for years in protected places.

Life stages present in the population were approximated by dissecting small numbers of cases (usually only 5–10) on each sample date and, for larvae, measuring widths of head capsules. Such measurements suggested four larval instars: I, 0.28–0.30 mm wide (n = 40); II, 0.36–0.40 mm (n = 16); III, 0.48–0.54 mm (n = 10); and IV, 0.64–0.80 mm (n = 9).

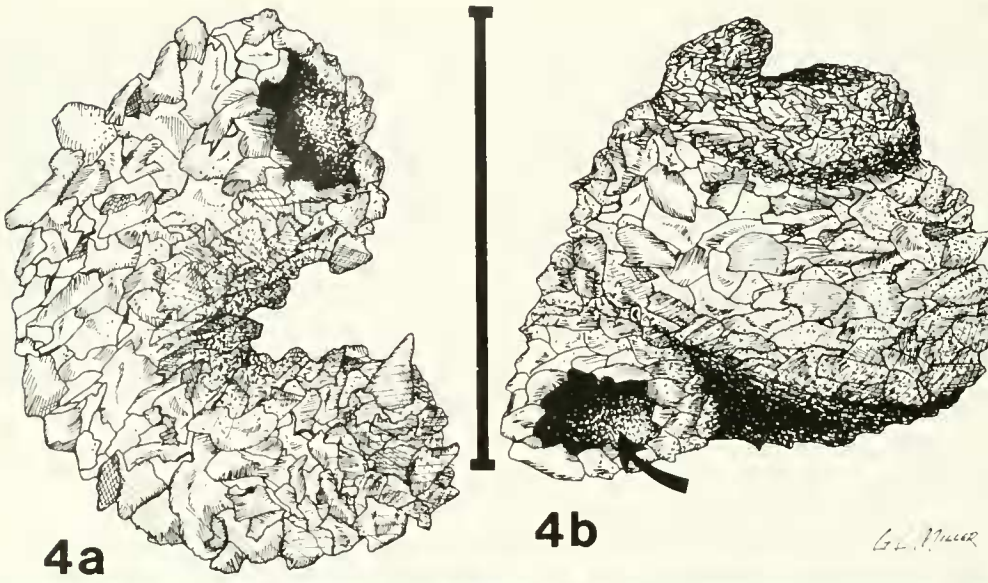
As Robinson (1953) reported for *A. helix* in California, young larvae overwinter within the female's pupal skin. Larvae apparently construct septa within this empty shell so that each is enclosed in its own cell (Davis 1964). In Pennsylvania during late March–early April, 14 occupied cases that were collected on guardrails and examined in the laboratory contained first instars. As many as 42 and 49 larvae emerged from a single case. Several cases were coated with clover mites, *Bryobia praetiosa* Koch, and their egg shells. When cases were brought into the laboratory, larvae soon emerged, began to construct their own cases from sand and soil of old cases, and to feed on foliage, the damage appearing as tiny, circular transparent areas (Fig. 1).

On 13 April, first instars, about 1 mm long and without cases, were active on guardrails, with a few larvae in small cases observed on nearby spotted knapweed, *Centaurea maculosa* Lam. (Asteraceae). These cases consisted merely of a few sand grains on the body. Some knapweed leaves

Figs. 1–3. Feeding damage to foliage by larval stages of *Apterona helix*. 1, Early-stage larvae (with small cases) feeding on black medic, *Medicago lupulina*, causing tiny, circular transparent areas. 2, Feeding injury by mature larvae to leaves of common mullein, *Verbascum thapsus*. 3, Feeding injury by mature larvae to black medic.

showed slight feeding symptoms similar to those observed in the laboratory. First instars were the only stage found in cases taken on 22 and 27 April (n = 7, 10) (Fig. 6). Of 5 larvae collected on 5 May, 3 were first and 2 were second instars; by 11 May only one first instar was present in a collection that contained 8 second instars; and only second instars were present on 18 May (n = 5). Cases observed during May were larger, consisting of a white silken sac impregnated with grains of sand and soil (Fig. 4a). Robinson (1953) described these cases as having the form of an inverted J or U. In May damage on knapweed foliage became more obvious.

Larvae feed mainly at night (Davis 1964). A larva feeds by using silk to fasten its case to a leaf and emerging through an opening near the bottom of the case (see Fig. 4b). It chews a hole in the adaxial or abaxial surface, inserts its head in the opening, and scrapes out tissue between the leaf surfaces, making a nearly oval mine. Davis (1964) noted that this injury closely resembles that made by lepidopteran larvae of the genus *Coleophora* (Coleophoridae). Two, three, or more windowlike areas were observed on some small leaves (Figs. 2, 3). According to Robinson (1953), fecal material is expelled through a lateral aperture in the upper or smallest whorl of the case.



Figs. 4–5. Larval cases of *Apterona helix*. 4a, Case of early-stage larva, consisting of small silken case impregnated with grains of sand and soil. 4b, Mature larval case, usually of 2½ to 3½ whorls; arrow indicates large basal opening through which the larva emerges to feed; scale line = 5 mm. 5, Aggregation of larval cases on trunk of tree sapling.

Ten cases collected on 2 June contained third instars; all nine taken on 21 June yielded fourth instars (Fig. 6). Mature larvae occupy the lower whorl (Robinson 1953, Davis 1964) of the helicoid or snail-like cases (Fig. 4b). On 15 July few active larvae were observed on knapweed, but closed cases were apparent and clumped on small trees (Fig. 5); several cases opened in the laboratory were found to contain pupae. Mature larvae also ascended guardrails for pupation, where current-season cases could not be distinguished in the field from those of previous seasons. At other localities utility poles were used as pupation sites, with large numbers of old cases occurring in cracks and crevices.

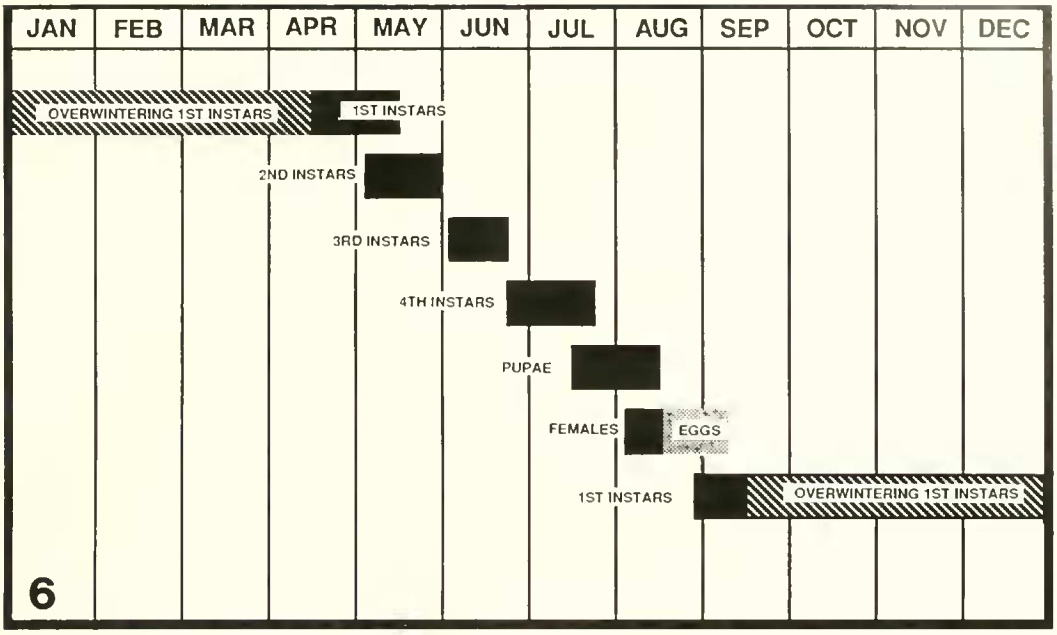


Fig. 6. Inferred seasonal history of *Apterona helix* in Pennsylvania. (Note: stippling indicates period when 1st instars are overwintering inside the female case.)

Females were found in several cases collected on 3 August. Robinson (1953) reported that yellowish-white eggs (about 25/case) were laid in the pupal skin that remains in the lower whorl and hatch in about 3 weeks; the diapausing larvae remain inside the case through the winter.

Seasonal history of the Pennsylvania population studied was nearly the same as that reported for *A. helix* in northern California (Robinson 1953). Overwintered first-instar larvae became active in mid-April and fed until early to mid-July, with females appearing to oviposit in August.

Host Plants

Spotted knapweed, the most frequently infested host at the study site in Lebanon Co., Pennsylvania, was the most common host plant observed along railroad lines in New York and Pennsylvania. White and yellow sweetclover, *Melilotus alba* Medik. and *M. officinalis* Lam. (Fabaceae), also were infested. The large population of *A. helix* at Solvay, New York, severely damaged these plants and several unidentified hosts. Species that showed occasional injury or moderate to heavy damage at only one or a few sites included green foxtail, *Setaria viridis* (L.) Beauv. (Poaceae); mugwort, *Artemisia vulgaris* L. (Asteraceae); black mustard, *Brassica nigra* (L.) Koch, and peppergrass, *Lepidium virginicum* L. (Brassicaceae); blueweed, *Echium vulgare* L. (Boraginaceae); common mullein, *Verbascum thapsus* L., and yellow toadflax, *Linaria vulgaris* Mill. (Scrophulariaceae); common evening-primrose, *Oenothera biennis* L. (Onagraceae); cinquefoil, *Potentilla* sp. (Rosaceae); buckhorn plantain, *Plantago lanceolata* L., and broadleaf plantain, *P. major* L. (Plantaginaceae); knotweed, *Polygonum* sp. (Polygonaceae); and crownvetch, *Coronilla varia* L., black medic, *Medicago lupulina* L., and alsike clover, *Trifolium hybridum* L. (Fabaceae).

Crownvetch was the dominant plant species at the Pennsylvania study site, but only slight feeding on leaflets of a few plants was observed. Along the railroad in New

York common plants that generally were avoided were hedge bindweed, *Calystegia sepium* (L.) R. Br. (Convolvulaceae); lambsquarters, *Chenopodium album* L. (Chenopodiaceae); chicory, *Cichorium intybus* L., and horseweed, *Conyza canadensis* (L.) Cronq. (Asteraceae); and Queen Anne's-lace, *Daucus carota* L. subsp. *carota* (Apiaceae).

Apterona helix, although a polyphagous insect known from various wild and cultivated plants (Robinson 1953, Davis 1964), fed mainly on low-growing herbs in New York and Pennsylvania. In California, however, Robinson (1953) noted that "foliage of shrubs and trees were freely attacked later in the season." We also observed some feeding on shrubs and trees at the study site and along railroad tracks, but these plants served primarily as sites for pupation (Fig. 5).

Recognition Features

The most characteristic morphological attribute of this small psychid moth is the larval case (Figs. 4a, 4b); it alone will enable recognition of this introduced bagworm moth in North America. The small spiraled case measures approximately 3–5 mm in diameter and 4–5 mm in depth. The mature larval case typically has 2½ to 3½ whorls and is constructed of silk overlain with minute earthen particles. There are three openings present in the case: a small apical opening, a large basal opening through which the larva is able to crawl and feed, and a large slitlike opening in the uppermost whorl through which the shrivelled female reportedly emerges after oviposition (Davis 1964).

Males of *A. helix* are not known. The parthenogenetic females are highly specialized, larviform, wingless or with reduced wings, with a small head with or without small antennal rudiments, with small pigment spots instead of eyes, and with leg rudiments without claws (Kozhanchikov 1956). The females never leave the spiral case.

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